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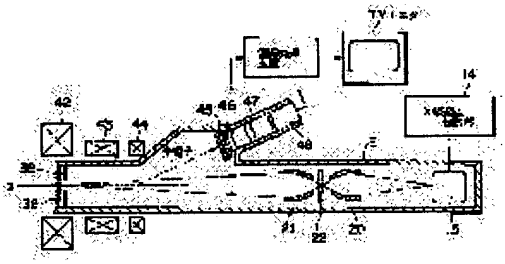
(54) IMAGING X-RAY MICROSCOPE

(57)Abstract:

PURPOSE: To obtain an imaging X-ray microscope having high mechanical strength and excellent in photoelectric conversion quantum efficiency in which distortion of image can be improved while reducing the size.

CONSTITUTION: X-rays emitted from an X-ray generating unit 15 is condensed through an X-ray condensing lens 20 and projected toward a sample 22. Transmitted X-rays are enlarged through an X-ray enlarging lens 21 and focused on a reflective X-ray electrooptic conversion face 38 arranged perpendicularly to the incident direction of the transmitted X-rays. Photoelectrons corresponding to the transmitted X-ray image are emitted from the conversion plane 38 and accelerated, by a field, in the direction normal to a plane emitting light reversely to the incident direction of the transmitted X-rays between the conversion plane 38 and an aperture electrode 39. Accelerated photoelectrons are then deflected in a predetermined direction through a deflection coil 44, multiplied through a microchannel plate 45, and converted on a fluorescent plane 46 into a visible light image which is picked up by a CCD camera 48 through an optical system 47 thus obtaining an enlarged X-ray image of the sample 22.



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CLAIMS

[Claim(s)]
[Claim 1] The image formation type X-ray microscope characterized by providing the following. The X-ray expansion section which expands the image of the transparency X-ray which penetrated the sample, and carries out image formation to the position in the aforementioned vacuum housing while being prepared in a vacuum housing. The reflected type X-ray electronic photo-electric-translation side which carries out vertical incidence of the image formation which has been arranged at the aforementioned position while being prepared in the vacuum housing, and was expanded in the aforementioned X-ray expansion section. The accelerating electrode which carries out acceleration discharge of the image of the photoelectron generated in the aforementioned reflected type X-ray electronic photo-electric-translation side to the direction of incidence and opposite direction of the aforementioned image formation while being prepared in a vacuum housing. The deviation section which deflects the image of the photoelectron accelerated by the aforementioned accelerating electrode in the predetermined direction, and the image pck-up section which changes and picturizes the image of the photoelectron deflected by the aforementioned deviation section to a visible light figure.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the image formation type X-ray microscope for expanding and observing radiolucent finding.
[0002]
[Description of the Prior Art] As technology relevant to the conventional image formation type X-ray microscope, there are some which were indicated by JP,3-134943,A and JP,5-4778,B. The transparency X-ray which these make a sample penetrate the X-ray emitted from X line source, and has the image information of the sample While expanding in the X-ray expansion section in which (it is hereafter called the image of a transparency X-ray) was prepared in the vacuum housing, in respect of penetrated type X-ray electronic photo electric translation A photoelectron (Corresponding to the image of a transparency X-ray, it is hereafter called the image of a photoelectron) It changes, and after accelerating the image of this photoelectron further and amplifying by the electron multiplier, it has composition which changes into a visible light figure in a phosphor screen, and is observed by the CCD camera etc.
[0003] Here, since the above-mentioned penetrated type X-ray electronic photo-electric-translation side carries out outgoing radiation of the image of the above-mentioned photoelectron in the same direction as the direction of incidence of the image of the above-mentioned transparency X-ray, X line source, the vacuum housing, and the CCD camera are arranged in series.
[0004] Moreover, a reflected type X-ray electronic photo-electric-translation side which is indicated by reference "ADV in E.E physics vol.64.B" is applied, and outgoing radiation and the thing to accelerate are also known with the predetermined tilt angle in the direction contrary to the direction where the image of the transparency X-ray has carried out incidence of the image of the photoelectron generated corresponding to the incidence of the image of a transparency X-ray. If the reflected type X-ray electronic photo-electric-translation side currently indicated by this reference is applied, since the direction of incidence of the image of a transparency X-ray and the direction of outgoing radiation of the image of a photoelectron are not the same directions, X line source, a vacuum housing, and a CCD camera are not arranged in series, consequently a short compact image formation type X-ray microscope can be realized to a longitudinal direction.
[0005]
[Problem(s) to be Solved by the Invention] If it was in the former technology (technology indicated by JP,3-134943,A and JP,5-4778,B), as mentioned above, since X line source, the vacuum housing, and the CCD camera had been arranged mostly at the serial, they became a microscope long in the direction of a structure superior hand, and there were problems, like large-sized and operability are substantially bad.
[0006] furthermore, the penetrated type X-ray electronic photo-electric-translation side applied to the former technology has become the structure where made into the ground the macromolecule thin film 1 which consists of the thickness of about about 100nm, and the laminating of about about 30nm Au layer 2 which is photo-electric-translation material, and about about 100nm CsI layer 3 was carried out to the front face of this macromolecule thin film 1 by vacuum evaporationo, as shown in the fragmentary sectional view of drawing 7 Furthermore, smoothness is secured by carrying out the laminating (from the macromolecule thin film a to a laminating) of this penetrated type X-ray electronic photo-electric-translation side on the front face of the photoelectric-surface support mesh electrode 4 as shown in the plan of drawing 8 . However, if it is in this penetrated type X-ray electronic photo-electric-translation side, since the transparency X-ray which carries out incidence is absorbed by the macromolecule thin film 1 for maintaining the mechanical structure intensity of the Au layer 2 and the CsI layer 3, there is a problem of receiving reduction of photoelectrical converted quantity child efficiency or the limit by the X-ray wavelength.
[0007] furthermore, if it is in the former technology, a penetrated type X-ray electronic photo-electric-translation side

is held in a vacuum housing, and the forcible exhaust air of the inside of the vacuum housing is carried out again -- things have realized vacuum atmosphere However, since it is difficult to make uniform the exhaust back pressure P1 concerning one field (side in which a transparency X-ray carries out incidence) of a penetrated type X-ray electronic photo-electric-translation side, and the exhaust back pressure P2 concerning the field (side in which a photoelectron carries out outgoing radiation) of another side of a penetrated type X-ray electronic photo-electric-translation side, When exhaust-back-pressure difference |P1-P2| beyond the mechanical strength of a penetrated type X-ray electronic photo-electric-translation side arose, there was a problem that a penetrated type X-ray electronic photo-electric-translation side received an injury. Furthermore, since it was easy to be influenced of such an exhaust back pressure, while receiving the limit in exhaust air or vacuum leak speed, the problem of being easy to damage a penetrated type X-ray electronic photo-electric-translation side was during work.

[0008] If it is in the latter technology (technology by the aforementioned reference), to the reflected type X-ray electronic photo-electric-translation side, right-angled, the image of a transparency X-ray carries out incidence, and has the composition of accelerating the image of a photoelectron in the tilt-angle direction, by the accelerating electrode leaned and arranged with the predetermined degree of tilt angle from the direction of incidence. Namely, the image of a photoelectron is accelerated in the predetermined tilt-angle direction by the high electric field built between this accelerating electrode and the photoelectric-emission side of a reflected type X-ray electronic photo-electric-translation side. However, since the photoelectric-emission side and the accelerating electrode were mutually installed by the predetermined degree of tilt angle, this control of high electric field was very difficult, all the photoelectrons produced in a photoelectric-emission side were not uniformly accelerated in the predetermined inclination direction, but there was a problem of inviting picture distortion.

[0009] this invention is accomplished in view of the technical problem of such conventional technology, and a mechanical strength is high, photoelectrical converted quantity child efficiency is excellent, picture distortion is improved, and it aims at offering the image formation type X-ray microscope which can attain the miniaturization of equipment.

[0010]

[Means for Solving the Problem] The X-ray expansion section which this invention expands the image of the transparency X-ray which penetrated the sample, and carries out image formation to a position in order to attain such a purpose, The reflected type X-ray electronic photo-electric-translation side which carries out vertical incidence of the image formation which has been arranged at the aforementioned position and expanded in the aforementioned X-ray expansion section, The accelerating electrode which carries out acceleration discharge of the image of the photoelectron generated in the aforementioned reflected type X-ray electronic photo-electric-translation side to the direction of incidence and opposite direction of the aforementioned image formation, It had the deviation section which deflects the image of the photoelectron accelerated by the aforementioned accelerating electrode in the predetermined direction, and the image pck-up section which changes and picturizes the image of the photoelectron deflected by the aforementioned deviation section to a visible light figure, and considered as the composition which prepares the aforementioned X-ray expansion section, a reflected type X-ray electronic photo-electric-translation side, and an accelerating electrode in a vacuum housing.

[0011]

[Function] According to the image formation type X-ray microscope of this invention which has this composition, the image of the transparency X-ray which penetrated the sample turns into an X-ray expansion image by the X-ray expansion section, and vertical incidence is carried out to a reflected type X-ray electronic photo-electric-translation side. In a reflected type X-ray electronic photo-electric-translation side, the image of a photoelectron is generated corresponding to the vertical incidence of this X-ray expansion image, and the image of this photoelectron is accelerated and emitted by the accelerating electrode in the reverse direction to the above-mentioned vertical-incidence direction. And in response to the influence of the magnetic field generated by the deviation section, the image of the photoelectron accelerated and emitted in this way is deflected from the middle in the predetermined direction, and is picturized by the image pck-up section prepared in the deviation direction.

[0012] Thus, after making the image of the photoelectron generated in a reflected type X-ray electronic photo-electric-translation side once accelerate and emit in the direction of a normal (reverse direction [as opposed to / the above-mentioned vertical-incidence direction / Namely,]), generating of picture distortion can be sharply reduced by making it deviate. Moreover, since the direction of incidence of a transparency X-ray and the radiation direction of a photoelectron turn into an opposite direction, the length of a vacuum housing becomes short and the miniaturization of equipment is realized substantially. By applying a reflected type X-ray electronic photo-electric-translation side, improvement in a mechanical strength and improvement in photoelectrical converted quantity child efficiency are achieved.

[0013]
[Example] Hereafter, one example of the image formation type X-ray microscope by this invention is explained with a drawing. First, if this whole image formation type X-ray microscope structure is explained based on drawing 1 The optical mirror room B which expands the image (it is hereafter called the image of a transparency X-ray) by the transparency X-ray which condensed the X-ray emitted from the X-ray generating section A which generates an X-ray, and this X-ray generating section A, irradiated the sample, and penetrated the sample While making a predetermined position carry out image formation of the transparency X-ray expanded at the optical mirror room B, changing into the image of a photoelectron according to the reflected type X-ray electronic photo-electric-translation side built in and doing acceleration and discharge of It has the reflected type X-ray zooming pipe section C which forms the video signal of an image to the sample image of the accelerated photoelectron, and the control section (not shown) which builds in the microcomputer system which controls operation of the whole microscope.
[0014] The X-ray generating section A, the optical mirror room B, and the reflected type X-ray zooming pipe section C are constituted in the vacuum housing E installed in the illustration longitudinal direction, and a part for each connection of the X-ray generating section A, and the optical mirror room B, and the optical mirror room B and the reflected type X-ray zooming pipe section C is connected through the vacuum gate valves 5 and 6.
[0015] The portion which the X-ray generating section A consists of among vacuum housings E The portion from which vacuum length is performed and which the optical mirror room B consists of with the evacuation pump and the gage 8 for degree of vacuum measurement by turbo-molecular-pump 7a and rotary-pump 7b The portion from which vacuum length is performed and which the reflected type X-ray zooming pipe section C consists of with the evacuation pump and the gage 10 for degree of vacuum measurement by turbo-molecular-pump 9a and rotary-pump 9b Drive control of vacuum length is performed by the evacuation pump and the gage 12 for degree of vacuum measurement by turbo-molecular-pump 11a and rotary-pump 11b. Therefore, original vacuum length and original vacuum leak are possible for the inside of a vacuum housing E for every portions of the X-ray generating section A, and the optical mirror room B and the reflected type X-ray zooming pipe section C.
[0016] The sample which should be measured is prepared in the optical mirror room B. In order to perform installation of this sample, or exchange of other samples, first, it is in the state which fastened the vacuum gate valves 5 and 6, and exchange operation is realized by performing vacuum leak of only the vacuum housing portion of the optical mirror room B, next installing a sample in the predetermined position of the optical mirror room B, and performing vacuum length again with turbo-molecular-pump 9a, the evacuation pump by rotary-pump 9b, and the gage 10 for degree of vacuum measurement. Thus, since a sample can be installed by simple work, shortening of working hours is possible.
[0017] furthermore, observation according to partial vibration by laying the portions of the optical mirror room B and the reflected type X-ray zooming pipe section C on the vibrationproofing stage 13 among vacuum housings E -- degradation of resolution is prevented
[0018] Next, the structure of each portion is explained in full detail. The gas puff type X line source controlled by the X-ray generating control section 14 is used for this X-ray generating section A, for example, it is N2 as used gas. Gas is used. The discharge electrode of a couple is built in in the X-ray generating unit 15, and the switching device 17 for impressing the gas introduction bulb 16 to the bottom, and impressing switching voltage to the bottom at a discharge electrode, the mass capacitor equipment 18 for supplying high tension power to a switching device 17, and the high-voltage power units 19a and 19b for making mass capacitor equipment 18 store electricity are formed.
[0019] N2 Gas is introduced into the above-mentioned discharge electrode in vacuum atmosphere in pulse through the gas introduction bulb 16, and a pillar-shaped gas lump is formed between these discharge electrodes. When the gas lump's gas density turns into high density of X-ray generating efficiency and a switching device 17 supplies the high tension power of mass capacitor equipment 18 to a discharge electrode, electric discharge is excited and it is N2 by this electric discharge. Gas is made to plasma-ize. And a plasma particle is accelerated in the direction of a shaft center of a discharge electrode by the current which flows this plasma, it becomes the plasma (pinch plasma) of elevated-temperature high density, and an X-ray is emitted. In addition, N2 By using gas, an X-ray with a wavelength of 2nm - 3nm occurs.
[0020] In the vacuum housing E by the side of X line emission of the X-ray generating section A, as shown in the fragmentary sectional view of drawing 2 , the Ti thin film 19 with a thickness of about 0.1 micrometers is formed, passage of the ultraviolet rays produced as soon as an X-ray occurs in the above-mentioned discharge electrode, a visible ray, and splash is intercepted, and only the X-ray of the above-mentioned wavelength is made to penetrate to the optical mirror room B. In addition, since the proper through hole is formed in the periphery portion of this Ti thin film 19, it has prevented that this Ti thin film 19 is damaged according to the exhaust air differential-pressure force at the time of evacuation.
[0021] Next, the composition of the optical mirror room B is explained based on the elements on larger scale of

drawing 2 . A predetermined interval is set in a vacuum housing E, the X-ray condensing mirror 20 and the X-ray expansion mirror 21 are arranged, and the sample electrode holder 23 for arranging a sample 22 is formed in the X-ray condensing position by the X-ray condensing mirror 20. in addition, all of both the X-ray condensing mirror 20 and the X-ray expansion mirror 21 are the same while the Walter type oblique incidence mirror is used -- optical -- it has NA and the expansion image formation of the maximum efficiency can be acquired now from the image of the transparency X-ray which penetrated the sample 22

[0022] Furthermore, when an examiner operates the multiaxial manipulator 24, a position, sense, etc. of the sample electrode holder 23 can be tuned finely, by operating the multiaxial manipulator 25, a position, sense, etc. of the X-ray condensing mirror 20 can be tuned finely, and a position, sense, etc. of the X-ray expansion mirror 21 can be finely tuned by operating the multiaxial manipulator 26. That is, condense the X-ray emitted from the X-ray generating section A, and it is made to irradiate to the target sample 22, and the image of the transparency X-ray which penetrated the sample 22 can be expanded, and the predetermined image formation side mentioned later can be made it to carry out clear image formation by tuning suitably the physical relationship of the sample electrode holder 23, the X-ray condensing mirror 20, and the X-ray expansion mirror 21 finely.

[0023] Furthermore, wearing in the sample electrode holder 23 of a sample 22 is performed by equipping with the sample cell 27 shown in drawing 3 and drawing 4 . In addition, drawing 3 shows the plan of a sample cell 27, and drawing 4 shows the X-X line view cross section of drawing 3 . That is, the sample cell 27 has 2nd spacer 28b of the shape of the minor diameter which O ring 29 is made to be placed between the through holes of 1st doughnut-like spacer 28a and 1st spacer 28a, and is fitted in them by the major diameter, and a doughnut, and any spacers 28a and 28b are formed in the thickness of about 1mm by the product made from stainless steel. Moreover, two or more female screw sections for an outer diameter being about 30mm, and spacer 28a making two or more screws 30 later mentioned to a circumferential side edge screw are formed. The bore of the through hole formed in a part for the center section of 2nd spacer 28b is about about 3mm, and it is used as a sample room 31 for this through hole holding a sample 22.

[0024] And where the predetermined sample 22 is held in the sample room 31 combining these [1st], and the 2nd Spacers 28a and 28b and O ring 29 The silicon-nitride thin films 32 and 33 of a circle configuration with a thickness of about 250 micrometers are put on the both sides of the 1st, the 2nd spacer 28a and 28b, and O ring 29, and it has structure which unifies the disc-like dummy supports 34 and 35 of further the product made from stainless steel with two or more bolts 30 in piles. And the whole thickness when being unified is set to about about 5.5mm. In addition, while the cone-like through hole of about about 5mm of diameters at the maximum equator is drilled in the central field W of dummy supports 34 and 35, the female screw section for screwing two or more above-mentioned bolts 30 is formed beforehand, and the sample apertures 36 and 37 with a thickness of about 100nm are further formed in the silicon-nitride thin films 32 and 33 by **********ing beforehand about a field [a little] narrower than the central field W. And if the sample electrode holder 23 is equipped with this sample cell 27, the X-ray condensed by the X-ray condensing mirror 22 will carry out incidence to a sample 22 through the central field W or the sample aperture 36 (or 37), and the image of the transparency X-ray which penetrated the sample 22 will spread to the X-ray expansion mirror 21 through the sample aperture 37 (or 36) or the central field W of an opposite side.

[0025] For example, in making living thing cells, such as a spatula cell (HeLa cell), into a sample 22, it seals a sample 22 with physiological sodium chloride solution in the sample room 31. Moreover, since the sample room 31 interior is maintained at one atmospheric pressure by it while the leakage by the exterior of physiological sodium chloride solution is prevented by operation of O ring 29, a sample 22 is observable in the state where it lived. Furthermore, since the X-ray of the water window area which carries out incidence to a sample 22 is alternatively absorbed in the organic substance's containing carbon existence portion, a transparency X-ray will have the information on the clear image about structure with a detailed living thing cell. And the image of the transparency X-ray which has this information is expanded to a predetermined scale factor by the X-ray expansion mirror 21, and image formation is carried out to the predetermined image formation position in the reflected type X-ray zooming pipe section C mentioned later.

[0026] Next, the structure of the reflected type X-ray zooming pipe section C is explained based on drawing 5 . In addition, drawing 5 is an expansion fragmentary sectional view. The reflected type X-ray electronic photo-electric-translation side 38 which generates a photoelectron in connection with the incidence of a transparency X-ray is established in the image formation side of the transparency X-ray from the X-ray expansion mirror 21, and the aperture electrode 39 set as the ground potential ahead of the reflected type X-ray electronic photo-electric-translation side 38 is being fixed to it. Au board with a thickness of about 1mm with which this reflected type X-ray electronic photo-electric-translation side 38 was attached in the point (edge which counters in the direction of incidence of a transparency X-ray) of the photoelectric-surface electrode 40 formed by Cu, and surface roughness was ground by 100nm or less, It consists of CsI layers by which vacuum evaporationo was carried out to the front face of the Au board

by the thickness of about 100nm, and the front face of Au board and the front face of a CsI layer are right-angled to the direction of incidence of a transparency X-ray.
[0027] And in the photoelectric-surface electrode 40, it is [about] by high-voltage-power-supply equipment 41. -The voltage of the range of 8kV or -10kV is impressed. A ground potential is impressed to the aperture electrode 39, and the reflected type X-ray electronic photo-electric-translation side 38 the photoelectron generated to the incidence of a transparency X-ray by the strong electric field generated between the reflected type X-ray electronic photo-electric-translation side 38 and the aperture electrode 39 It emits in the direction (namely, the direction of a normal of the light-emission side of the reflected type X-ray electronic photo-electric-translation side 38) contrary to the direction of incidence of a transparency X-ray, and is made to accelerate.
[0028] Furthermore, the 1st electromagnetic lens 42, the 2nd electromagnetic lens 43, and deflecting coils 44 are formed successively by the reflected type X-ray zooming pipe section C at the front side side of the reflected type X-ray electronic photo-electric-translation side 38. The 1st and the 2nd electromagnetic lens 42 and 43 make the photoelectron which was outputted from the reflected type X-ray electronic photo-electric-translation side 38, and was accelerated by the aperture electrode 39 expand by the expansion magnetic field, and complete it in a predetermined convergence distance. By changing the ratio of the magnetism which the current passed to the 1st electromagnetic lens 42 and 2nd electromagnetic lens 43 is changed, and is generated in a vacuum housing E, even if this dilation ratio does not change convergence distance, it can be continuously changed in the about 10 times or 200 times as many range as this. In addition, in this example, convergence distance is set as 70cm from the photoelectric-emission side of the reflected type X-ray electronic photo-electric-translation side 38.
[0029] It is made for a deflecting coil 44 to run in the direction of the micro channel plate 45 of a two-sheet tandem by generating a deviation magnetic field in a vacuum housing E, and deflecting the photoelectron it has run along with the line of magnetic force of the 1st and the expansion magnetic field of the 2nd electromagnetic lens 42 and 43 by the predetermined deflection angle. The distance W1 from the center of the deviation magnetic field in this example, the deflection angle of a photoelectron is set as 9 degrees to the incident-light shaft of a transparency X-ray, and according to a deflecting coil 44 to the photoelectric-emission side of the reflected type X-ray electronic photo-electric-translation side 38, The sum total distance of the distance W2 from the center of this deviation magnetic field to the photoelectron plane of incidence of a micro channel plate 45 is set as 70cm, and this sum total distance is the 1st and the expansion convergence distance of the 2nd electromagnetic lens 35 and 36 further. Therefore, without barring the incidence of the transparency X-ray, it is expanded in the above-mentioned expansion magnetic field, and the image of the photoelectron generated corresponding to the image of the transparency X-ray by which image formation was carried out on the reflected type X-ray electronic photo-electric-translation side 38 is deflected by the predetermined deflection angle, and projection image formation is carried out to the photoelectron plane of incidence of a micro channel plate 45.
[0030] In addition, the electric power supply to the 1st, and the 2nd electromagnetic lenses 42 and 43 and deflecting coil 44 is performed from the non-illustrated power supply for a drive.
[0031] A micro channel plate 45 is 105 at the maximum by applying the voltage within the limits of about 500V or about 2000v. A twice as many electronic multiplication factor as this is set up, further, incidence of the electron by which electronic multiplication was carried out is carried out to the phosphor screen 46 which was accelerated by the electric field by the applied voltage of 3000V, and was prepared behind the micro channel plate 45, and it is changed into a visible light figure.
[0032] Behind a phosphor screen 46, the optical system 47 which contains a relay lens is formed, and a visible image is further picturized by CCD camera 48 prepared in the image formation side of optical system 47. And the video signal outputted from CCD camera 48 is transmitted to an image processing system, and it is indicated by the still picture at a television monitor etc.
[0033] Drawing 6 shows roughly the structure and the function of an image formation type X-ray microscope in which it explained above. And the image of the photoelectron generated when the image of the transparency X-ray which penetrated the sample 22 in accordance with X linear-light shaft Q shown according to a two-dot chain line among this drawing carries out incidence to the reflected type X-ray electronic photo-electric-translation side 38 It will deviate, after the photoelectron produced in the reflected type X-ray electronic photo-electric-translation side 38 carries out outgoing radiation uniformly according to a drift potential, since it deviates by the aperture electrode 39 in the direction contrary to the direction of incidence of the transparency X-ray, and it is made to deviate in the predetermined direction with a deflecting coil 44 after carrying out outgoing radiation, acceleration and. therefore, in the Prior art (reference "ADV in E.Ephysics vol.64.B") mentioned above By setting up so that a drift potential may be beforehand inclined and built to the photoelectric-emission side of the reflected type X-ray electronic photo-electric-translation side 38, in deciding the run direction of a photoelectron As opposed to the discharge direction of a photoelectron

changing with becoming less uniform and causing picture distortion, since the electric-field distribution to this photoelectric-emission side is not uniform in this example Since a photoelectron is emitted uniformly and it is made to deviate in the predetermined direction after that, since electric field are imposed so that a photoelectron may be made to emit in the direction of a normal to a photoelectric-emission side, and it picturizes in CCD camera 48 grade, picture distortion will be reduced sharply.

[0034] Furthermore, since the reflected type X-ray electronic photo-electric-translation side 38 does not have a support mesh electrode and a macromolecule thin film (refer to drawing 8) unlike a penetrated type X-ray electronic photo-electric-translation side and there is no limit in Au layer thickness prepared in order photoelectrical converted quantity child efficiency is excellent and to raise photoelectrical converted quantity child efficiency, it can aim at improvement in photoelectrical converted quantity child efficiency in the range of a hard X ray from a soft X ray. Furthermore, since a charge can be supplied in the direction of a normal from a photoelectric-surface electrode to the photoelectric-emission side of the reflected type X-ray electronic photo-electric-translation side 38, photoelectrical each one resistance falls and a high current can be passed again. Moreover, since the mechanical strength is high compared with a penetrated type X-ray electronic photo-electric-translation side, the reflected type X-ray electronic photo-electric-translation side 38 does not receive damage etc. under the influence of the differential pressure produced with the vacuum length in a vacuum housing E etc. Moreover, in this example, since generating of the differential pressure produced with vacuum length etc. by establishing the reflected type X-ray electronic photo-electric-translation side 38 in the vacuum housing portion of the reflected type X-ray zooming pipe C is prevented beforehand, improvement in a mechanical strength is achieved.

[0035]

[Effect of the Invention] After making the image of the photoelectron generated in a reflected type X-ray electronic photo-electric-translation side once accelerate and emit in the direction of a normal (reverse direction [as opposed to / the direction of incidence of the image of a transparency X-ray / Namely,]) according to this invention, it is made to deviate, as explained above, and since it was made to picturize by the image pck-up section prepared in the deviation direction, generating of picture distortion can be reduced sharply. Moreover, since the direction of incidence of a transparency X-ray and the radiation direction of a photoelectron turn into an opposite direction, the length of a vacuum housing becomes short and the miniaturization of equipment is realized substantially. By applying a reflected type X-ray electronic photo-electric-translation side, the image formation type X-ray microscope which has the effect which was [achieve / improvement in photoelectrical converted quantity child efficiency and improvement in a mechanical strength] excellent can be offered.

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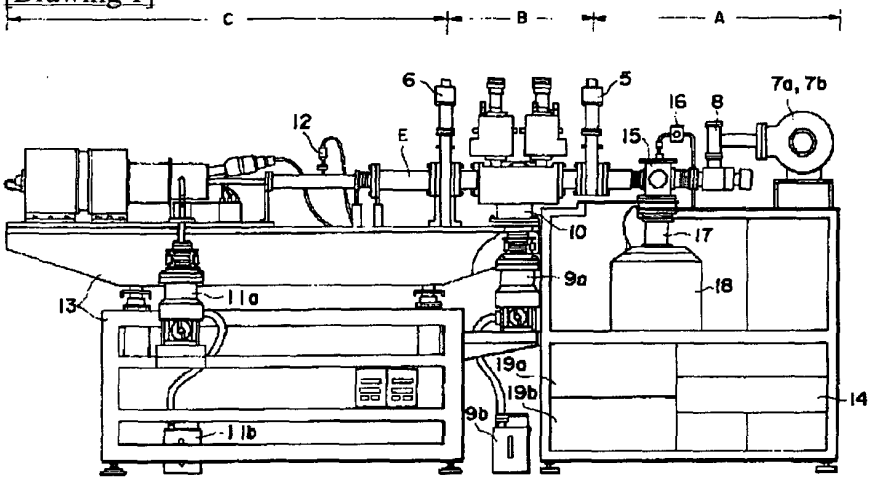
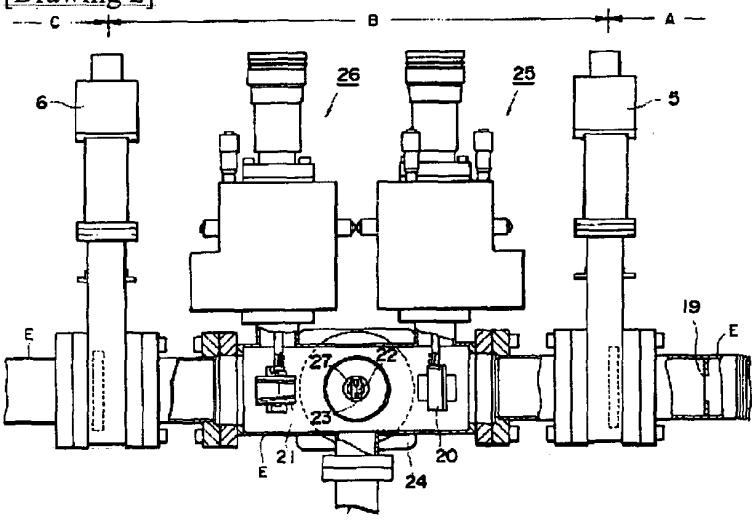
DRAWINGS

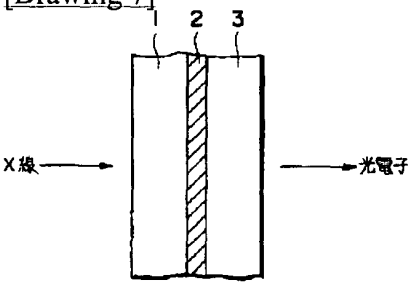
[Drawing 1]



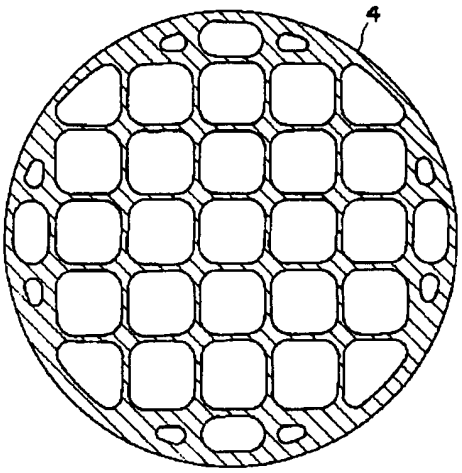
[Drawing 2]



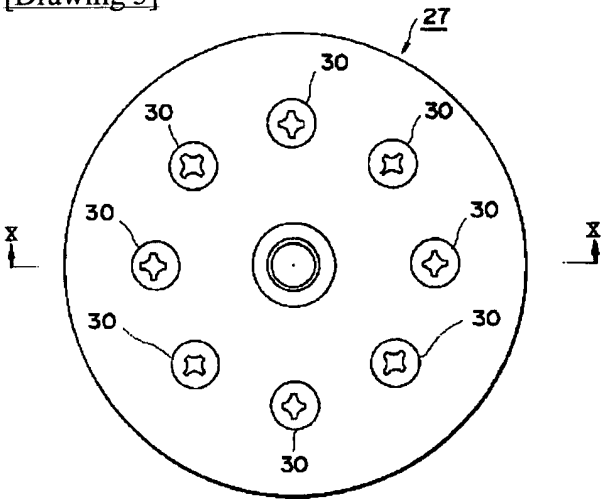
[Drawing 7]



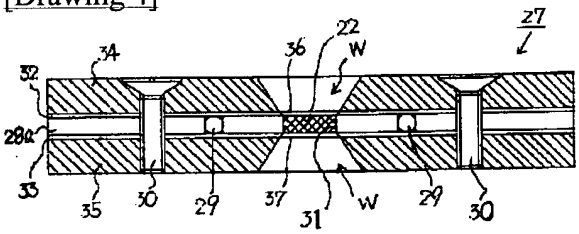
[Drawing 8]



[Drawing 3]



[Drawing 4]



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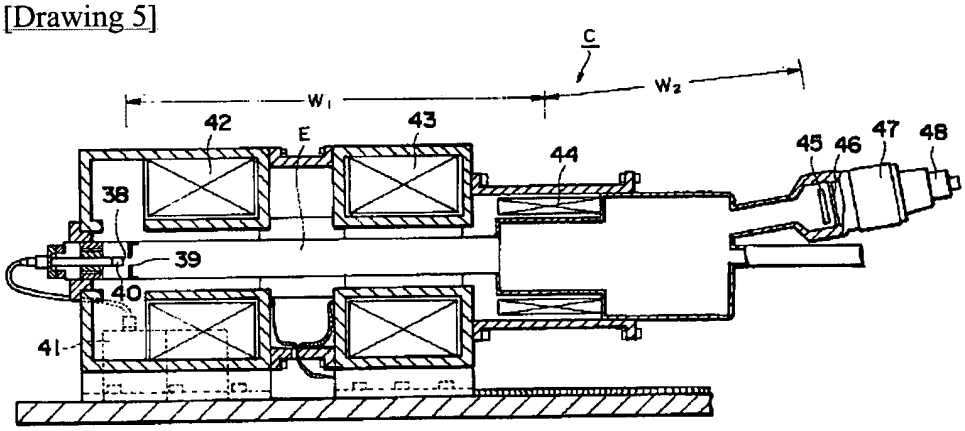

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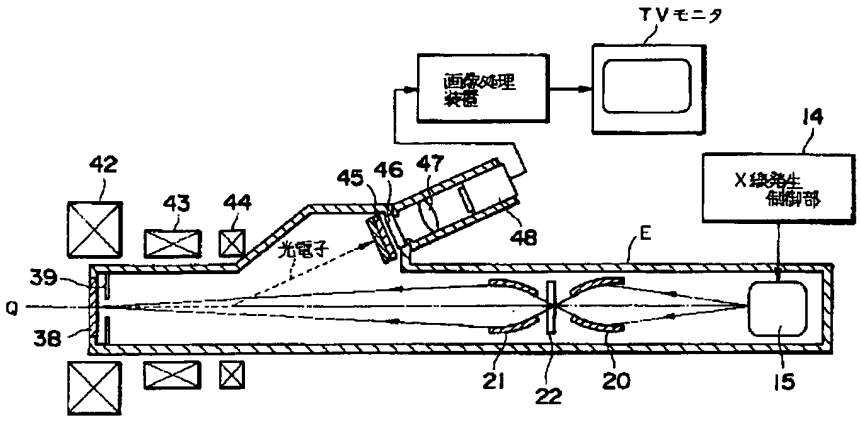

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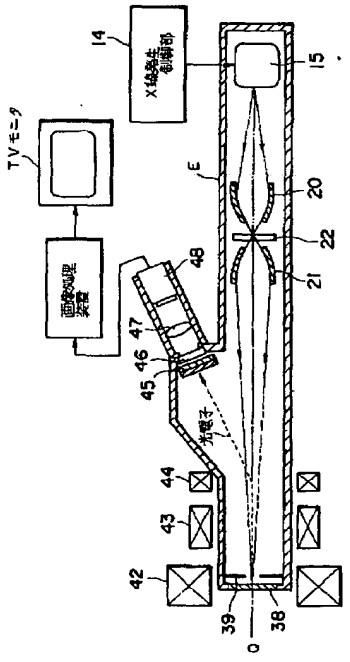
最終頁に続く

(54)【発明の名称】　結像型Ｘ線顕微鏡

(57)【要約】

【目的】　機械的強度が高く、光電変換量子効率が優れ、画像歪みを改善し、装置の小形化を図ることができる結像型Ｘ線顕微鏡を提供する。

【構成】　Ｘ線発生ユニット(15)から出射されたＸ線をＸ線集光レンズ(20)で集光して試料(22)に照射し、それを透過した透過Ｘ線をＸ線拡大レンズ(21)で拡大して反射型Ｘ線電子光電変換面(38)に結像させる。この反射型Ｘ線電子光電変換面(38)は透過Ｘ線の入射方向に対して直角に配置されている。反射型Ｘ線電子光電変換面(38)からは透過Ｘ線結像に対応して光電子が発生し、反射型Ｘ線電子光電変換面(38)とアパーチャ電極(39)との間に電界によって透過Ｘ線の入射方向とは逆方向（光放出面に対して法線方向）へ加速させる。偏向コイル(44)が加速された光電子を所定の方向へ偏向させ、マイクロチャンネルプレート(45)で電子増倍し、蛍光面(46)で可視光像に変換し、光学系(47)を介してＣＣＤカメラ(48)で試料(22)のＸ線拡大像を撮像する。



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【特許請求の範囲】

【請求項１】　真空容器内に設けられると共に、試料を透過した透過Ｘ線の像を拡大して前記真空容器内の所定の位置に結像させるＸ線拡大部と、

真空容器内に設けられると共に前記所定の位置に配置され、前記Ｘ線拡大部で拡大された結像を垂直入射する反射型Ｘ線電子光電変換面と、

真空容器内に設けられると共に、前記反射型Ｘ線電子光電変換面に発生する光電子の像を前記結像の入射方向と逆方向へ加速放出させる加速電極と、

前記加速電極により加速された光電子の像を所定方向へ偏向させる偏向部と、

前記偏向部により偏向された光電子の像を可視光像に変換して撮像する撮像部と、を備えたことを特徴とする結像型Ｘ線顕微鏡。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、Ｘ線透過像を拡大して観測するための結像型Ｘ線顕微鏡に関する。

【０００２】

【従来の技術】従来の結像型Ｘ線顕微鏡に関連する技術としては、特開平３－１３４９４３号や特公平５－４７７８号に開示されたものがある。これらは、Ｘ線源から放射されたＸ線を試料に透過させ、その試料の画像情報を有する透過Ｘ線（以下、透過Ｘ線の像と呼ぶ）を真空容器内に設けられたＸ線拡大部で拡大すると共に透過型Ｘ線電子光電変換面で光電子（以下、透過Ｘ線の像に対応して光電子の像と呼ぶ）とに変換し、更にこの光電子の像を加速させて電子増倍部で増幅した後、蛍光面にて可視光像に変換してＣＣＤカメラ等で観測する構成となっている。

【０００３】ここで、上記の透過型Ｘ線電子光電変換面は、上記の透過Ｘ線の像の入射方向と同じ方向へ上記の光電子の像を出射するので、Ｘ線源と真空容器及びＣＣＤカメラが、直列に配置されている。

【０００４】又、文献「ADV in E.E physics vol.64.B」に記載されているような反射型Ｘ線電子光電変換面を適用し、透過Ｘ線の像の入射に対応して発生する光電子の像を、その透過Ｘ線の像の入射してきた方向とは逆の方向へ所定傾斜角をもって出射・加速させるものも知られている。この文献に開示されている反射型Ｘ線電子光電変換面を適用すると、透過Ｘ線の像の入射方向と光電子の像の出射方向が同一方向でないので、Ｘ線源と真空容器及びＣＣＤカメラが直列に配置されず、その結果、長手方向に短いコンパクトな結像型Ｘ線顕微鏡を実現することができる。

【０００５】

【発明が解決しようとする課題】前者の技術（特開平３－１３４９４３号や特公平５－４７７８号に開示された技術）にあっては、前述したように、Ｘ線源と真空容器及びＣＣＤカメラが、ほぼ直列に配置されるので構造上長手方向に長い顕微鏡となり、実質的に大型且つ操作性が悪い等の問題があった。

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【０００６】更に、前者の技術に適用される透過型Ｘ線電子光電変換面は、図７の部分断面図に示す如く、約１００ｎｍ程度の厚さから成る高分子薄膜１を下地とし、この高分子薄膜１の表面に、光電変換材料である約３０ｎｍ程度のＡｕ層２と、約１００ｎｍ程度のＣｓＩ層３とが蒸着により積層された構造となっている。更に、かかる透過型Ｘ線電子光電変換面は、図８の平面図に示すような光電面支持メッシュ電極４の表面上に積層（高分子薄膜ａから積層）されることにより、平面性が確保されている。しかし、かかる透過型Ｘ線電子光電変換面にあっては、入射する透過Ｘ線が、Ａｕ層２とＣｓＩ層３との機械的構造強度を保つための高分子薄膜１により吸収されるために、光電変換量子効率の減少若しくはそのＸ線波長による制限を受けるという問題がある。

【０００７】更に又、前者の技術にあっては、透過型Ｘ線電子光電変換面を真空容器内に収容して、その真空容器内を強制排気することにより真空雰囲気を実現している。しかし、透過型Ｘ線電子光電変換面の一方の面（透過Ｘ線の入射する側面）に掛かる排気抵抗Ｐ１と透過型Ｘ線電子光電変換面の他方の面（光電子の出射する側面）に掛かる排気抵抗Ｐ２とを一様にすることが困難であるため、透過型Ｘ線電子光電変換面の機械的強度を超えた排気抵抗差｜Ｐ１－Ｐ２｜が生じることによって、透過型Ｘ線電子光電変換面が損傷を受けるという問題があった。更に、このような排気抵抗の影響を受け易いことから、排気又は真空リーク速度に制限を受けると共に、作業中に透過型Ｘ線電子光電変換面を損傷し易いという問題があった。

【０００８】後者の技術（前記文献による技術）にあっては、反射型Ｘ線電子光電変換面に対して直角に透過Ｘ線の像が入射し、その入射方向より所定の傾斜角度で傾けて配置された加速電極により、光電子の像をその傾斜角方向へ加速させる構成となっている。即ち、この加速電極と反射型Ｘ線電子光電変換面の光電子放出面との間に掛かる高電界により光電子の像を所定の傾斜角方向へ加速させる。しかし、光電子放出面と加速電極は相互に所定の傾斜角度に設置されているので、この高電界の制御が極めて困難であり、光電子放出面に生じる光電子の全てが所定の傾斜方向へ一様に加速されず、画像歪みを招来するという問題があった。

【０００９】本発明はこのような従来技術の課題に鑑みて成されたものであり、機械的強度が高く、光電変換量子効率が優れ、画像歪みを改善し、装置の小形化を図ることができる結像型Ｘ線顕微鏡を提供することを目的とする。

【００１０】

【課題を解決するための手段】このような目的を達成す

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るために本発明は、試料を透過した透過Ｘ線の像を拡大して所定の位置に結像させるＸ線拡大部と、前記所定の位置に配置され前記Ｘ線拡大部で拡大された結像を垂直入射する反射型Ｘ線電子光電変換面と、前記反射型Ｘ線電子光電変換面に発生する光電子の像を前記結像の入射方向と逆方向へ加速放出させる加速電極と、前記加速電極により加速された光電子の像を所定方向へ偏向させる偏向部と、前記偏向部により偏向された光電子の像を可視光像に変換して撮像する撮像部とを備え、前記Ｘ線拡大部と反射型Ｘ線電子光電変換面と加速電極を真空容器内に設ける構成とした。

【００１１】

【作用】かかる構成を有する本発明の結像型Ｘ線顕微鏡によれば、試料を透過した透過Ｘ線の像がＸ線拡大部によりＸ線拡大像となり、反射型Ｘ線電子光電変換面に垂直入射される。反射型Ｘ線電子光電変換面にはこのＸ線拡大像の垂直入射に対応して光電子の像が発生し、この光電子の像は加速電極により上記垂直入射方向に対して逆の方向へ加速・放出される。そして、このように加速・放出された光電子の像は、偏向部によって発生される磁界の影響を受けて、途中から所定の方向へ偏向され、その偏向方向に設けられている撮像部により撮像される。

【００１２】このように、反射型Ｘ線電子光電変換面に発生する光電子の像を一旦法線方向（即ち、上記垂直入射方向に対して逆の方向）へ加速・放出させた後に、偏向させることにより、画像歪みの発生を大幅に低減することができる。また、透過Ｘ線の入射方向と光電子の放射方向が逆方向となるので、真空容器の長さが短くなり実質的に装置の小形化を実現する。反射型Ｘ線電子光電変換面を適用することにより、機械的強度の向上と、光電変換量子効率の向上が図られている。

【００１３】

【実施例】以下、本発明による結像型Ｘ線顕微鏡の一実施例を図面と共に説明する。まず、図１に基づいてこの結像型Ｘ線顕微鏡の全体構造を説明すると、Ｘ線を発生するＸ線発生部Ａと、このＸ線発生部Ａから放射されたＸ線を集光して試料に照射しその試料を透過した透過Ｘ線による像（以下、透過Ｘ線の像と呼ぶ）を拡大する光学ミラー室Ｂと、光学ミラー室Ｂで拡大された透過Ｘ線を所定位置に結像させ、内蔵されている反射型Ｘ線電子光電変換面により光電子の像に変換して加速・放出させると共に、その加速された光電子の像から試料像の映像信号を形成する反射型Ｘ線ズーミング管部Ｃと、顕微鏡全体の動作を制御するマイクロコンピュータシステム等を内蔵する制御部（図示せず）を備えている。

【００１４】Ｘ線発生部Ａ、光学ミラー室Ｂ及び反射型Ｘ線ズーミング管部Ｃは、図示長手方向に延設された真空容器Ｅ内に構成され、Ｘ線発生部Ａと光学ミラー室Ｂ及び光学ミラー室Ｂと反射型Ｘ線ズーミング管部Ｃの夫々の接続部分が、真空ゲートバルブ５，６を介して接続されている。

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【００１５】真空容器Ｅの内、Ｘ線発生部Ａが構成される部分は、ターボ分子ポンプ７ａとロータリーポンプ７ｂとによる真空排気ポンプと真空度測定用ゲージ８によって真空引きが行われ、光学ミラー室Ｂが構成される部分は、ターボ分子ポンプ９ａとロータリーポンプ９ｂとによる真空排気ポンプと真空度測定用ゲージ１０によって真空引きが行われ、反射型Ｘ線ズーミング管部Ｃが構成される部分は、ターボ分子ポンプ１１ａとロータリーポンプ１１ｂとによる真空排気ポンプと真空度測定用ゲージ１２によって真空引きの駆動制御が行われる。よって、真空容器Ｅ内は、Ｘ線発生部Ａと光学ミラー室Ｂ及び反射型Ｘ線ズーミング管部Ｃの各部分毎に、独自の真空引きと、独自の真空リークが可能となっている。

【００１６】測定すべき試料は光学ミラー室Ｂ内に設けられる。かかる試料の設置又は他の試料の交換を行うには、まず、真空ゲートバルブ５，６を締めた状態で、光学ミラー室Ｂの真空容器部分のみの真空リークを行い、次に、光学ミラー室Ｂの所定位置に試料を設置し、再びターボ分子ポンプ９ａとロータリーポンプ９ｂによる真空排気ポンプと真空度測定用ゲージ１０によって真空引きを行うことにより、交換操作が実現される。このように、簡素な作業で試料の設置を行うことができるので、作業時間の短縮化が可能である。

【００１７】更に、真空容器Ｅの内、光学ミラー室Ｂ及び反射型Ｘ線ズーミング管部Ｃの部分が、防振ステージ１３上に載置されることにより、分割振動による観察分解能の劣化を防止している。

【００１８】次に、各部分の構造を詳述する。このＸ線発生部Ａには、Ｘ線発生制御部１４により制御されるガスパフ型Ｘ線源が用いられ、例えば、使用ガスとしてN_2ガスが用いられる。Ｘ線発生ユニット１５内には一対の放電電極が内蔵されており、その上側にはガス導入バルブ１６、その下側には放電電極にスイッチング電圧を印加するためのスイッチング装置１７と、スイッチング装置１７に高圧電力を供給するための大容量コンデンサ装置１８と、大容量コンデンサ装置１８を蓄電させるための高電圧電源装置１９ａ，１９ｂが設けられている。

【００１９】N_2ガスはガス導入バルブ１６を介して真空雰囲気中の上記放電電極にパルス的に導入され、かかる放電電極間に柱状のガス塊が形成される。そのガス塊のガス密度がＸ線発生効率の高い密度となったときに、スイッチング装置１７が放電電極に大容量コンデンサ装置１８の高圧電力を供給することにより、放電を励起させ、この放電によりN_2ガスをプラズマ化させる。そして、このプラズマを流れる電流によりプラズマ粒子は放電電極の軸中心方向へ加速され、高温高密度のプラズマ（ピンチプラズマ）となってＸ線が放出される。尚、N_2ガスを使用することにより、２ｎｍ～３ｎｍの波長の

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X線が発生する。

【００２０】X線発生部AのX線放出側の真空容器E内には、図２の部分断面図に示すように、約０．１μmの厚さのTi薄膜１９が設けられており、上記の放電電極においてX線が発生するのと同時に生じる紫外線と可視光線及び飛沫の通過を遮断して、上記波長のX線のみを光学ミラー室Bへ透過させる。尚、このTi薄膜１９の外周部分には適宜の貫通穴が形成されているので、真空排気時の排気差動圧力によってこのTi薄膜１９が破損することを防止している。

【００２１】次に光学ミラー室Bの構成を図２の部分拡大図に基づいて説明する。真空容器E内に、所定の間隔をおいてX線集光ミラー２０とX線拡大ミラー２１が配置され、X線集光ミラー２０によるX線集光位置に、試料２２を配置するための試料ホルダー２３が設けられている。尚、X線集光ミラー２０とX線拡大ミラー２１は共にウォルター型斜入射ミラーが用いられると共に、いずれも同一の光学的NAを有し、試料２２を透過した透過X線の像から最大効率の拡大結像を得ることができるようになっている。

【００２２】更に、試験者が多軸マニュピレータ２４を操作することによって試料ホルダー２３の位置や向き等を微調整することができ、多軸マニュピレータ２５を操作することによってX線集光ミラー２０の位置や向き等を微調整することができ、多軸マニュピレータ２６を操作することによってX線拡大ミラー２１の位置や向き等を微調整することができるようになっている。即ち、試料ホルダー２３とX線集光ミラー２０及びX線拡大ミラー２１の位置関係を適宜に微調整することにより、X線発生部Aから放出されたX線を集光して目的の試料２２へ照射させ、試料２２を透過した透過X線の像を拡大して、後述する所定の結像面に鮮明結像させることができる。

【００２３】更に、試料２２の試料ホルダー２３への装着は、図３及び図４に示す試料セル２７を装着することによって行われるようになっている。尚、図３は試料セル２７の平面図、図４は図３のX－X線矢視断面を示す。即ち、試料セル２７は、大径でドーナッツ状の第１のスペーサー２８aと、第１のスペーサー２８aの貫通穴にOリング２９を介在させて嵌装される小径且つドーナッツ状の第２のスペーサ２８bを有しており、いずれのスペーサー２８a，２８bもステンレス製で約１mmの厚さに形成されている。又、スペーサー２８aは、外径が約３０mmであり、且つ、周側端には後述する複数のネジ３０を螺合させるための複数の雌ネジ部が形成されている。第２のスペーサー２８bの中央部分に形成された貫通穴の内径が約３mm程度であり、この貫通穴が試料２２を収容するための試料室３１として使用される。

【００２４】そして、これら第１，第２のスペーサー２

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８a，２８bとOリング２９を組み合わせて試料室３１に所定の試料２２を収容した状態で、第１，第２のスペーサー２８a，２８bとOリング２９の両側に、約２５０μmの厚さの円形状の窒化珪素薄膜３２，３３を重ね、更にステンレス製の円板状支持金具３４，３５を重ねて複数個のボルト３０で一体化する構造となっている。そして、一体化されたときの全体の厚さは約５．５mm程度となる。尚、支持金具３４，３５の中央領域Wには最大直径約５mm程度の円錐状貫通穴が穿設されると共に、上記複数のボルト３０を螺合するための雌ネジ部が予め形成されており、更に、窒化珪素薄膜３２，３３には、中央領域Wより若干狭い領域について予めエッチングされることにより約１００nmの厚さの試料窓３６，３７が形成されている。そして、この試料セル２７を試料ホルダー２３に装着すると、X線集光ミラー２２により集光されたX線が中央領域Wないし試料窓３６（又は３７）を介して試料２２に入射し、試料２２を透過した透過X線の像が試料窓３７（又は３６）ないし反対側の中央領域Wを介してX線拡大ミラー２１へ伝搬する。

【００２５】例えば、ヘラ細胞（HeLa細胞）等の生物細胞を試料２２とする場合には、試料室３１内に生理的食塩水と共に試料２２を密封する。又、Oリング２９の作用により、生理的食塩水の外部への漏れが防止されると共に、試料室３１内部が１気圧に保たれることから、試料２２を生きた状態で観察することができる。更に、試料２２に入射するウォーターウィンドウ領域のX線は、炭素を含む有機物の存在部分で選択的に吸収されるので、透過X線は、生物細胞の微細な構造に関する明瞭な像の情報を有することとなる。そして、かかる情報を有する透過X線の像は、X線拡大ミラー２１で所定倍率に拡大され、後述する反射型X線ズーミング管部C内の所定の結像位置に結像される。

【００２６】次に反射型X線ズーミング管部Cの構造を図５に基づいて説明する。尚、図５は、拡大部分断面図である。X線拡大ミラー２１からの透過X線の結像面には、透過X線の入射に伴って光電子を発生する反射型X線電子光電変換面３８が設けられ、反射型X線電子光電変換面３８の前方にはグランド電位に設定されたアパーチャ電極３９が固定されている。この反射型X線電子光電変換面３８は、Cuで形成された光電面電極４０の先端部（透過X線の入射方向に対向する端部）に嵌着され且つ表面粗さが１００nm以下に研磨された約１mmの厚さのAu板と、そのAu板の表面に約１００nmの厚さで蒸着されたCsI層で構成され、Au板の表面とCsI層の表面は、透過X線の入射方向に対して直角となっている。

【００２７】そして、光電面電極４０には、高圧電源装置４１により約－８kVないし－１０kVの範囲の電圧が印加され、アパーチャ電極３９にはグランド電位が印

加され、反射型Ｘ線電子光電変換面３８が透過Ｘ線の入射に対して発生した光電子を、反射型Ｘ線電子光電変換面３８とアパーチャ電極３９との間に発生する強電界によって、透過Ｘ線の入射方向とは逆の方向（即ち、反射型Ｘ線電子光電変換面３８の光放出面の法線方向）へ放出して加速させる。

【００２８】更に、反射型Ｘ線ズーミング管部Ｃには、反射型Ｘ線電子光電変換面３８の前方横側に、第１の電磁レンズ４２と第２の電磁レンズ４３、及び偏向コイル４４が連設されている。第１，第２の電磁レンズ４２，４３は、反射型Ｘ線電子光電変換面３８から出力されてアパーチャ電極３９により加速された光電子を、拡大磁場により拡大させ且つ所定の収束距離で収束させる。この拡大率は第１の電磁レンズ４２と第２の電磁レンズ４３に流す電流を変化させて真空容器Ｅ内に発生する磁力の比率を変えることで、収束距離を変化させなくとも約１０倍ないし２００倍の範囲で連続的に変化させることができるようになっている。尚、この実施例では、収束距離は、反射型Ｘ線電子光電変換面３８の光電子放出面から７０ｃｍに設定されている。

【００２９】偏向コイル４４は、真空容器Ｅ内に偏向磁場を発生させ、第１，第２の電磁レンズ４２，４３の拡大磁場の磁力線に沿って走行してきた光電子を、所定の偏向角で偏向させることにより、２枚タンデムのマイクロチャンネルプレート４５の方向へ走行させる。この実施例では、光電子の偏向角が透過Ｘ線の入射光軸に対して９°に設定され、偏向コイル４４による偏向磁場の中心から反射型Ｘ線電子光電変換面３８の光電子放出面までの距離Ｗ１と、この偏向磁場の中心からマイクロチャンネルプレート４５の光電子入射面までの距離Ｗ２の合計距離が７０ｃｍに設定されており、更にこの合計距離が、第１，第２の電磁レンズ３５，３６の拡大収束距離となっている。したがって、反射型Ｘ線電子光電変換面３８上に結像された透過Ｘ線の像に対応して発生する光電子の像は、その透過Ｘ線の入射を妨げることなく、上記拡大磁場で拡大され且つ所定の偏向角で偏向されて、マイクロチャンネルプレート４５の光電子入射面に投影結像される。

【００３０】尚、第１，第２の電磁レンズ４２，４３と偏向コイル４４への電力供給は、不図示の駆動用電源から行うようになっている。

【００３１】マイクロチャンネルプレート４５は、約５００Ｖないし約２０００Ｖの範囲内の電圧が掛けられることにより、最大で10^5倍の電子増倍率が設定され、更に、電子増倍された電子は３０００Ｖの印加電圧による電界により加速されてマイクロチャンネルプレート４５の後方に設けられた蛍光面４６に入射し、可視光像に変換される。

【００３２】蛍光面４６の後方には、リレーレンズを内蔵する光学系４７が設けられ、更に、光学系４７の結像面に設けられたＣＣＤカメラ４８によって、可視像を撮像するようになっている。そして、ＣＣＤカメラ４８から出力される映像信号は画像処理装置に伝送され、テレビジョンモニタ等に静止画表示される。

【００３３】図６は、以上に説明した結像型Ｘ線顕微鏡の構造及び機能を概略的に示している。そして、同図中、２点鎖線で示すＸ線光軸Ｑに沿って試料２２を透過した透過Ｘ線の像が反射型Ｘ線電子光電変換面３８に入射することにより発生する光電子の像を、その透過Ｘ線の入射方向とは逆の方向へアパーチャ電極３９により加速・出射させた後、偏向コイル４４によって所定の方向へ偏向させるので、反射型Ｘ線電子光電変換面３８に生じる光電子が加速電界に従って一様に出射した後に偏向されることとなる。したがって、前述した従来の技術（文献「ADV in E.Ephysics vol.64.B」）では、反射型Ｘ線電子光電変換面３８の光電子放出面に対して予め加速電界が傾斜して掛かるように設定することで、光電子の走行方向を決める場合には、この光電子放出面に対する電界分布が一様でないために、光電子の放出方向が一様でなくなり画像歪みを招くことと成るのに対し、この実施例では、光電子放出面に対して法線方向へ光電子を放出させるように電界が掛けられているので、光電子は一様に放出され、その後に所定の方向へ偏向させてＣＣＤカメラ４８等で撮像するので、画像歪みが大幅に低減されることとなる。

【００３４】更に、反射型Ｘ線電子光電変換面３８は、透過型Ｘ線電子光電変換面とは異なり、支持メッシュ電極と高分子薄膜（図８参照）を有しないので、光電変換量子効率が優れ、又、光電変換量子効率を向上させるために設けられるＡｕ層の厚さに制限がないことから、軟Ｘ線から硬Ｘ線の範囲において光電変換量子効率の向上を図ることができる。更に又、反射型Ｘ線電子光電変換面３８の光電子放出面に対して光電面電極から法線方向へ電荷を供給することができるので、光電面面抵抗が下がり、大電流を流すことができる。又、反射型Ｘ線電子光電変換面３８は、透過型Ｘ線電子光電変換面と比べて機械的強度が高いので、真空容器Ｅ内の真空引き等によって生じる差圧の影響で損傷等を受けない。又、この実施例では、反射型Ｘ線ズーミング管Ｃの真空容器部分に反射型Ｘ線電子光電変換面３８を設けることにより、真空引き等によって生じる差圧の発生を予め防止しているので、機械的強度の向上が図られている。

【００３５】

【発明の効果】以上に説明したように本発明によれば、反射型Ｘ線電子光電変換面に発生する光電子の像を一旦法線方向（即ち、透過Ｘ線の像の入射方向に対して逆の方向）へ加速・放出させた後に偏向させ、その偏向方向に設けられた撮像部により撮像するようにしたので、画像歪みの発生を大幅に低減することができる。また、透過Ｘ線の入射方向と光電子の放射方向が逆方向となるの

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で、真空容器の長さが短くなり実質的に装置の小形化を実現する。反射型Ｘ線電子光電変換面を適用することにより、光電変換量子効率の向上と、機械的強度の向上が図られる等の優れた効果を有する結像型Ｘ線顕微鏡を提供することができる。

【図面の簡単な説明】

【図１】本発明による結像型Ｘ線顕微鏡の一実施例の全体構成を示す平面図である。

【図２】光学ミラー室の構造を示す部分断面図である。

【図３】試料セルの構造を示す平面図である。

【図４】試料セルの構造を示す断面図である。

【図５】反射型Ｘ線ズーミング管部の構造を示す部分断面図である。

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【図６】結像型Ｘ線顕微鏡の全体構造を概念的に示す断面図である。

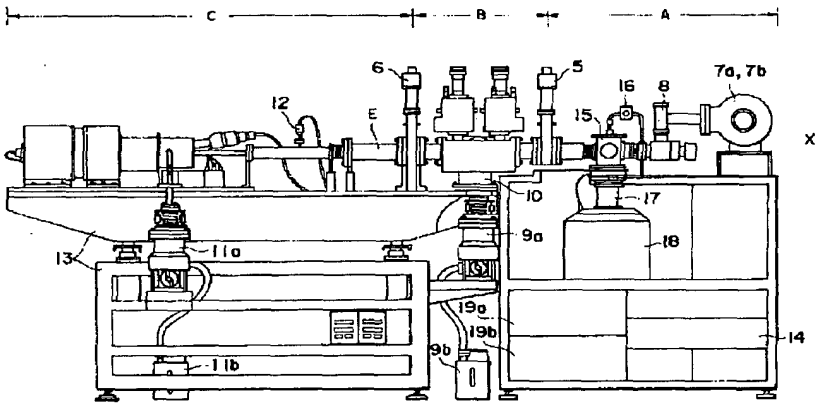
【図７】透過型Ｘ線電子光電変換面の構造を示す部分断面図である。

【図８】透過型Ｘ線電子光電変換面に使用される光電面支持メッシュ電極の構造を示す平面図である。

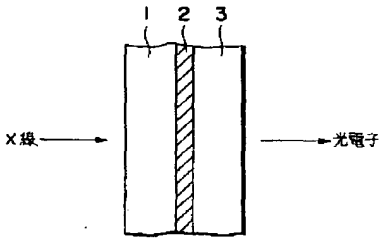
【符号の説明】

２０…Ｘ線集光ミラー、２１…Ｘ線拡大ミラー、２２…試料、２３…試料ホルダー、３８…反射型Ｘ線電子光電変換面、３９…アパーチャ電極、４２，４３…電磁レンズ、４４…偏向コイル、４５…マイクロチャンネルプレート、４６…蛍光面、４７…光学系、４８…ＣＣＤカメラ。

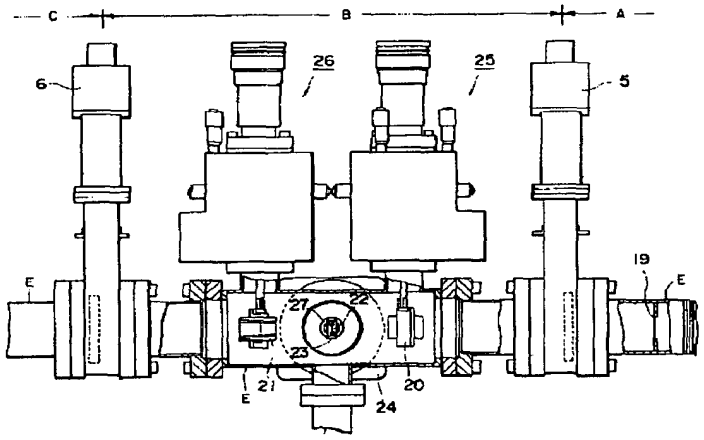
【図１】



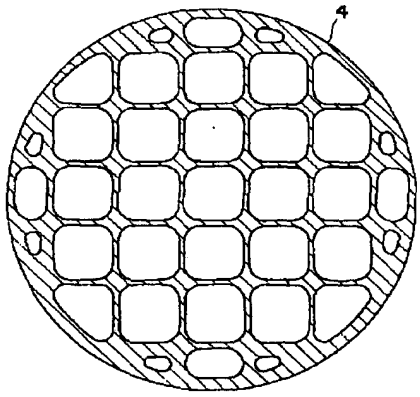
【図７】



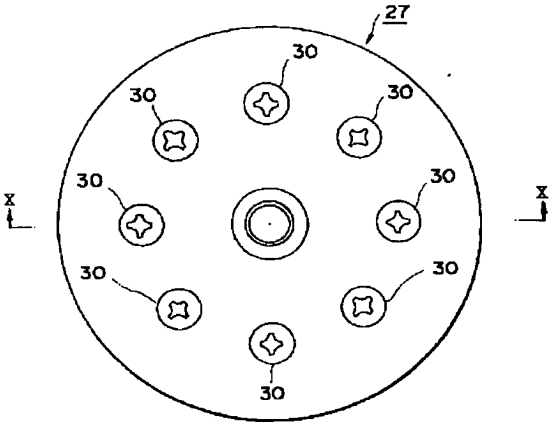
【図２】



【図８】



【図３】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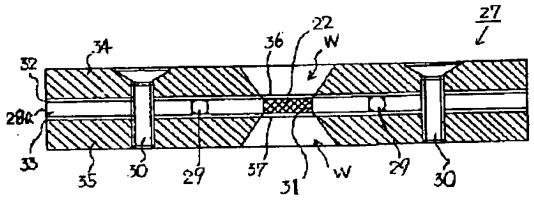
【図４】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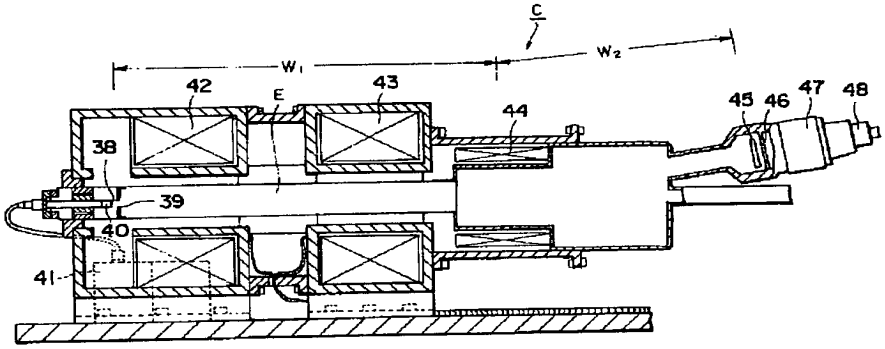
【図５】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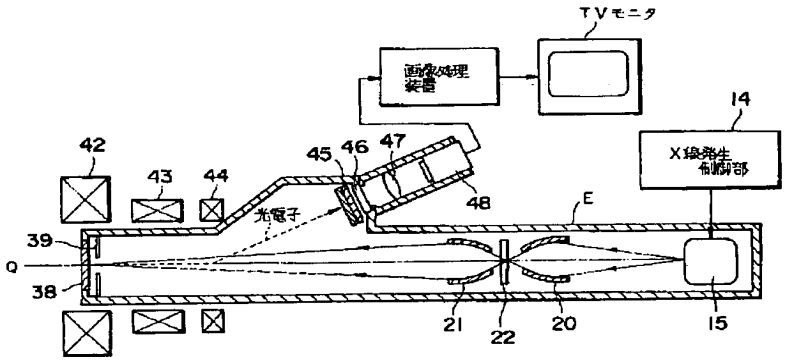
【図６】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